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Transformation of structurally similar elements of technical system

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Selecting analogs

One of the fundamental ideas of TRIZ is that all technical systems evolve in accordance with objective cognizable laws. These laws underlie all the principle solving TRIZ tools, first of all, Principles of Technical Contradiction Solving, Standards for Solving Inventive Problems, and, certainly, ARIZ. The high efficiency of TRIZ tools is due to the high degree of generalization and universality. This universality is result from analytical processing of large volumes of technical and patent information and distinguishing a number of general principles. One and the same principle may be used in solving various types of problems.

At the other extremity of the generalization degree scale, there is such TRIZ tool as Evolution Lines. They are extremely specific because, in the general case, they describe evolution of a certain element of a certain technical system. (It should be specified that some lines describe evolution of a technical system as a whole). The simplest and fastest problem-solving method is analogy. It is enough to find a respective analog for a specific situation. Experienced problem solvers accumulate the problems they solved to form their own databases. By using these databases they easily find analogs for new problems. However, newcomers do not have databases of their own. But they can use analogs incorporated in the TRIZ tools themselves.

There arises a problem. The thing is that tools based on generalization offer universal solutions. Correspondingly, using one and the same tool may give technically absolutely different solutions. As a result, analogs are not easy to find among the obtained solutions since they are not always obvious. A specific technical solution depends on the structure of the system elements to be transformed, as well as on the parameters to be improved and available resources.

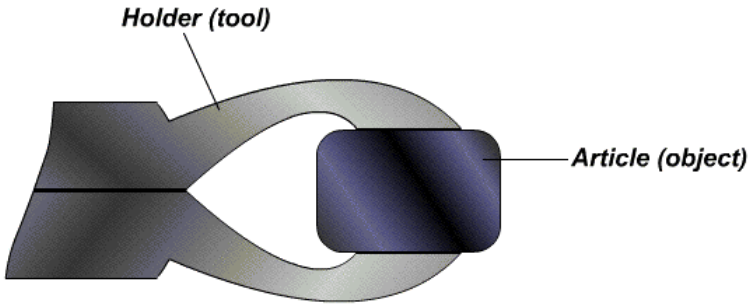
A contrary situation occurs when building an evolution line of a technical system. In this case, transformations of various objects and their elements often coincide making the analogy obvious. This coincidence is due to the fact that transformation of one element may employ a comparatively small number of resources. (When for increasing the transformation ideality certain limitations are imposed on the introduction of additional resources - systems, objects, substances and fields). But each line describes development of one specific element. That hampers the use of evolution lines of technical systems for solving inventive problems. For analyzing a technical system, it is necessary to resort to its element-by-element transformation. This results in cumbersome analytical constructions.

Structural similarity

It is much more convenient to deal not with individual objects, but with aggregates of objects that form certain structures. The most suitable ones are two-element structures consisting of a tool and an object to be treated that perform a certain function.

For example:
Holder is tool and article is object. They perform a function "To hold an object". Such structure may be part of number different technical systems. (Fig. 01)

Elementary Function

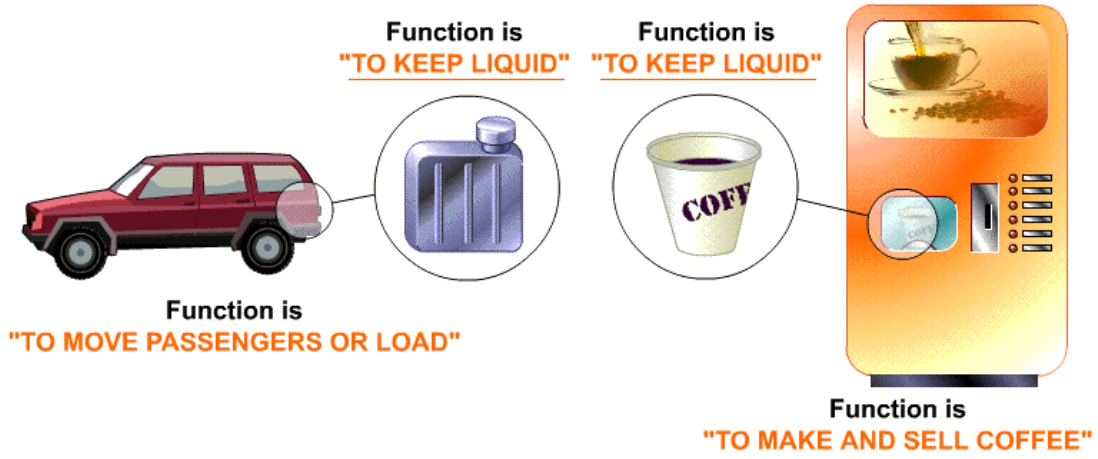


Function is "TO HOLD AN OBJECT"

With a sufficient degree of generalization, one can notice that some structures of absolutely different technical systems may be similar. This is especially obvious in case they perform similar functions. It should be emphasized that the main useful functions of technical systems that include the compared structures may be different. We are now speaking about elementary functions performed by parts of a technical system.

For example:
Main useful function of a car is "To move passengers or load". This technical system contains among other parts two-elements structure: a fuel tank and fuel in it. Function of the structure is: "To keep liquid". A coffee machine performs main useful function "To make and sell coffe". Part of this technical system is a paper cup which contains the coffee. A cup and coffee is two-elements structure with function "To keep liquid". A cup with coffee and a tank with fuel have the similar function and the similar structure: "Shell and Filler". (Fig. 02)

Similar Structures in Different Technical Systems

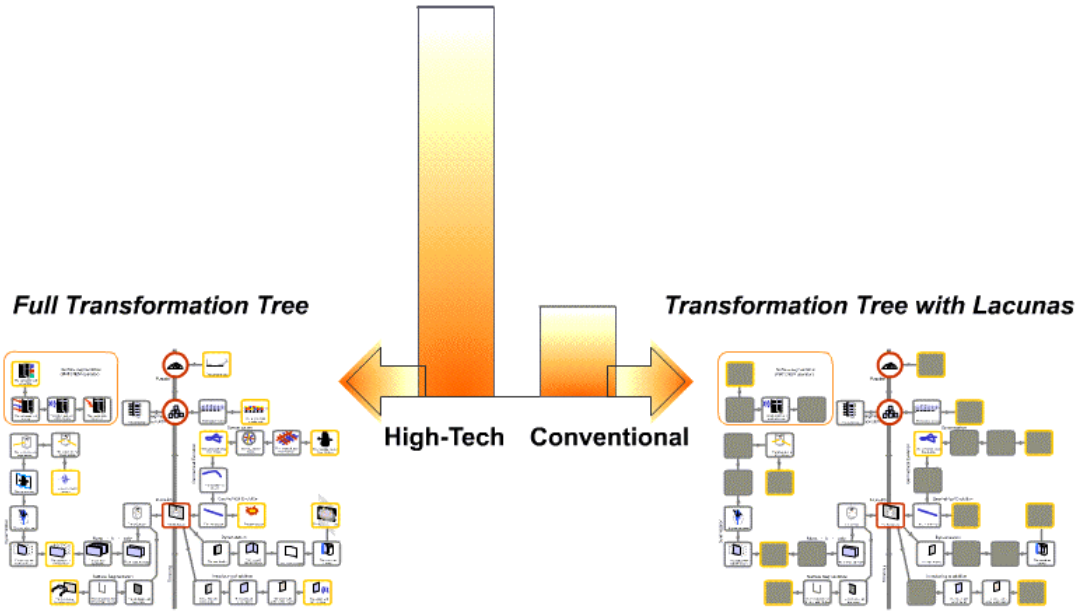


With such an approach, we can analyze a selected structure and search for transformation alternatives by using analogy with transformations of another structure which has been more thoroughly elaborated.

In the world of technology, the degree of elaboration of various technical systems is different. For instance, best specialists, scientific potential and huge financial resources are involved in the development of the automotive industry or creation of space technologies. No wonder that their technical systems and elements are maximally developed. By studying the evolution of such systems, it is possible to built very detailed evolution lines of their elements. And then to use these lines for building transformation trees having practically no missing steps.

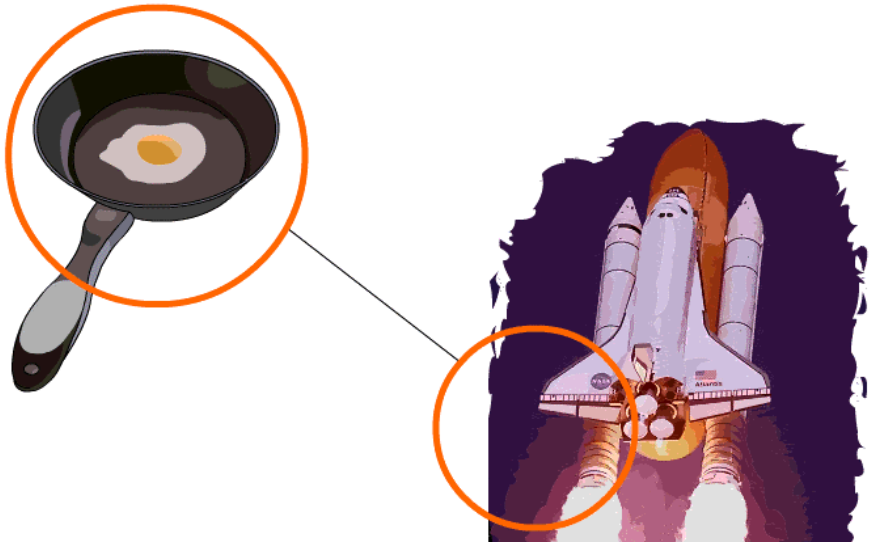
Alongside the well-elaborated technical systems, there exist technical systems which were designed by fewer people and which involved fewer scientific and financial resources. No wonder that the evolution lines of some elements of these systems have lacunas, blind spots. It is not always possible to continue such an incomplete line, to build trends and give a reliable forecast. *(Fig. 03)*

Transformation Trees



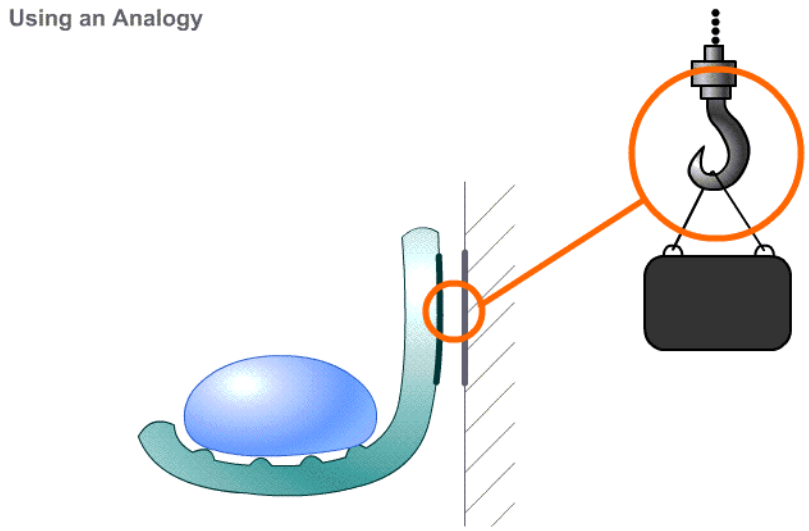
In other words, to invent a new pan, it is worth searching for analogies that occur while analyzing, for instance, a rocket nozzle. *(Fig. 04)*

Example for Inventing

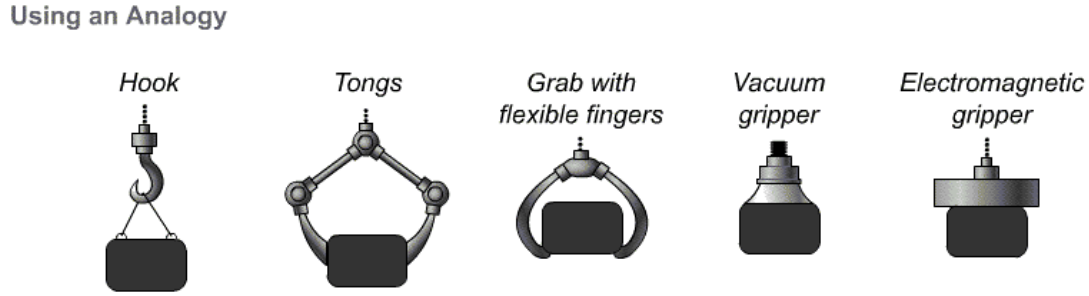


For example, when searching for variants of attaching a detachable soap dish to a wall, one may use an analogy with a load-handling fixture. Fixture is composed of a holding device with an attached load. *(Fig. 05).* This is how the evolution line of such fixture could look:

Hook
Tongs
Grab with flexible fingers
Vacuum gripper

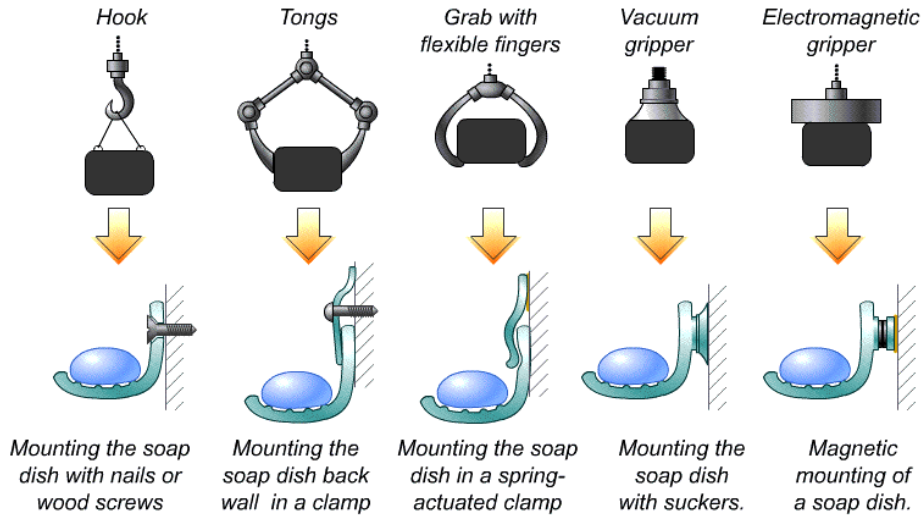


Electromagnetic gripper. (Fig. 06)



Correspondingly, the soap dish mounting alternatives may look as follows:
Mounting the soap dish with nails or wood screws
Mounting the soap dish back wall in a clamp
Mounting the soap dish in a spring-actuated clamp
Mounting the soap dish with suckers.
Magnetic mounting of a soap dish. (Fig. 07)

Using an Analogy



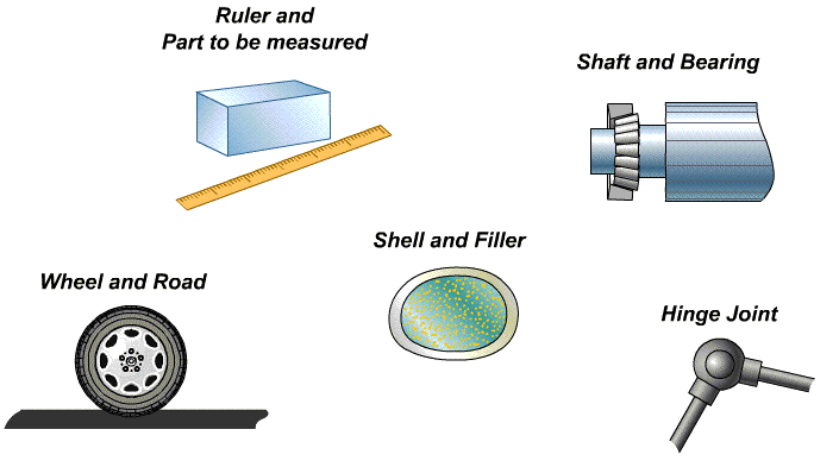
Thus, by analogy with a load-handling fixture, we can obtain a series of conceptions for an absolutely different technical system having a different main function.

Comparing transformations of similar structure

To prove or refute the above described conception, our group including Nikolay Shpakovsky, Peter Chuksin, Hyo June Kim, and Elena Novitskaya has analyzed some structural schemes composed of interacting *"Tool"* and *"Object to be treated"*:

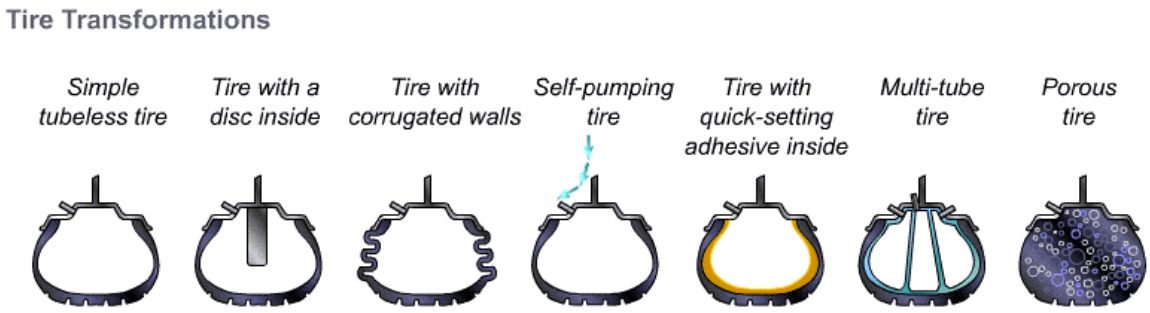
"A wheel and a Road",
"A Ruler and a Part to be measured",
"A Shaft and a Bearing",
"A Hinge Joint",
"A Shell and Filler". (Fig. 08)

Structural Schemes



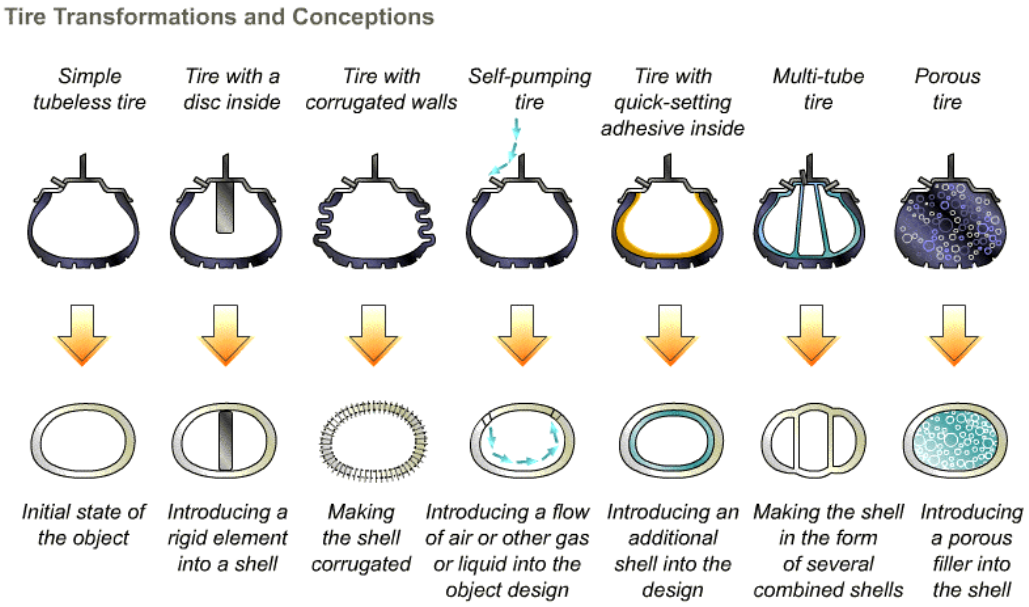
Let us dwell upon the structure that includes “A Shell” and “Filler”. We have examined over forty objects that correspond to this scheme. They are *a tire, a vacuum flask, a parachute canopy, a boat, a car* (both a boat and a car may be considered as a shell-body with filler-passengers), *an air-balloon, a bulb, a house, a submarine, a fuel tank, a shoe* and so on. *(Fig. 09)*

The fullest tree of transformations may be built for a tire. We have chosen it as a basic analog for comparing the transformations of other objects under investigation.
We randomly selected some transformations from several trends:
“Simple tubeless tire”
“Tire with a disc inside”
“Tire with corrugated walls”
“Self-pumping tire”
“Tire with quick-setting adhesive inside”
“Multi-tube tire”
“Porous tire”. (Fig. 10)

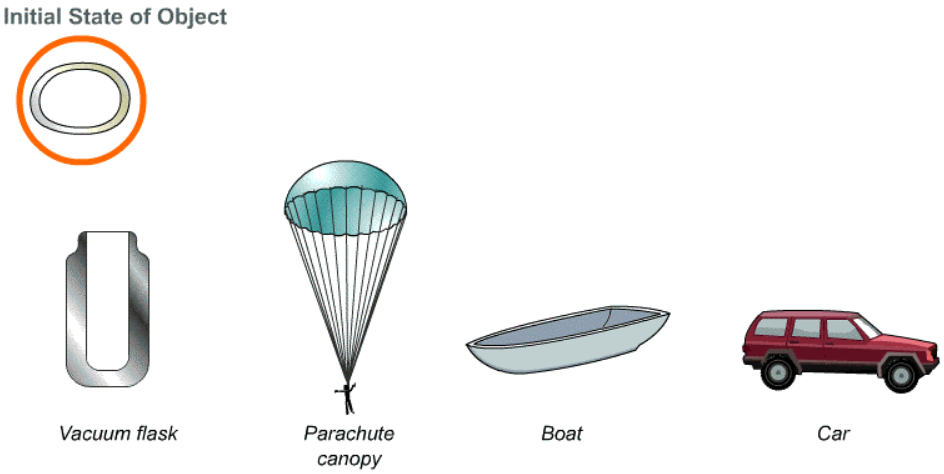


Let us formulate conceptions that correspond to these transformations:
«Simple tubeless tire» is *“Initial state of the object”.*
«Tire with a disc inside» gives a conception *“Introducing a rigid element into a shell”.*
«Tire with corrugated walls» gives a conception *“Making the shell corrugated”.*
«Self-pumping tire» gives a conception *“Introducing a flow of air or other gas or liquid into the object design”.*

«Tire with quick-setting adhesive inside» gives a conception *“Introducing an additional shell into the design”.*
«Multi-tube tire» gives a conception *“Making the shell in the form of several combined shells”.*
And «Porous tire» gives a conception *“Introducing a porous filler into the shell”. (Fig. 11)*

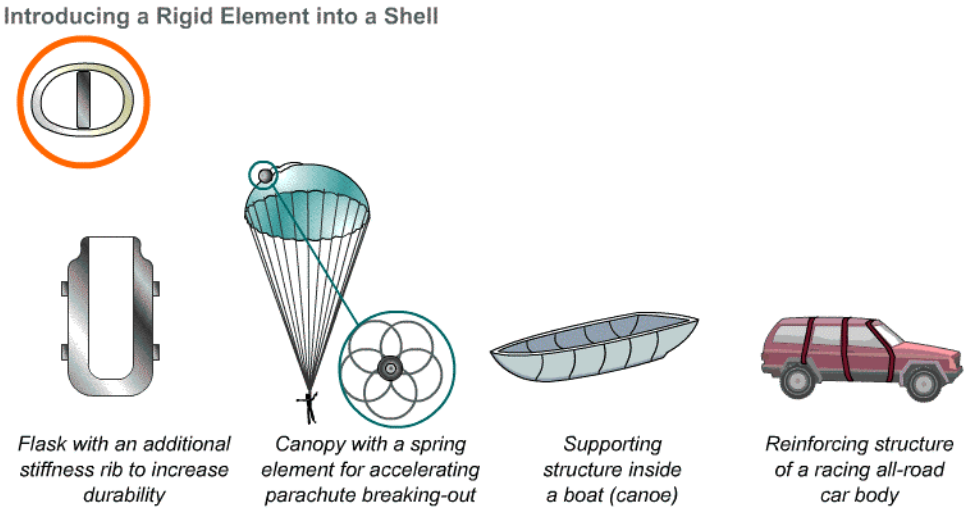


Let us check the transformation for:
Vacuum flask.
Parachute canopy.
Boat.
Car.
They are “ *Initial states of the objects”*. *(Fig. 12)*

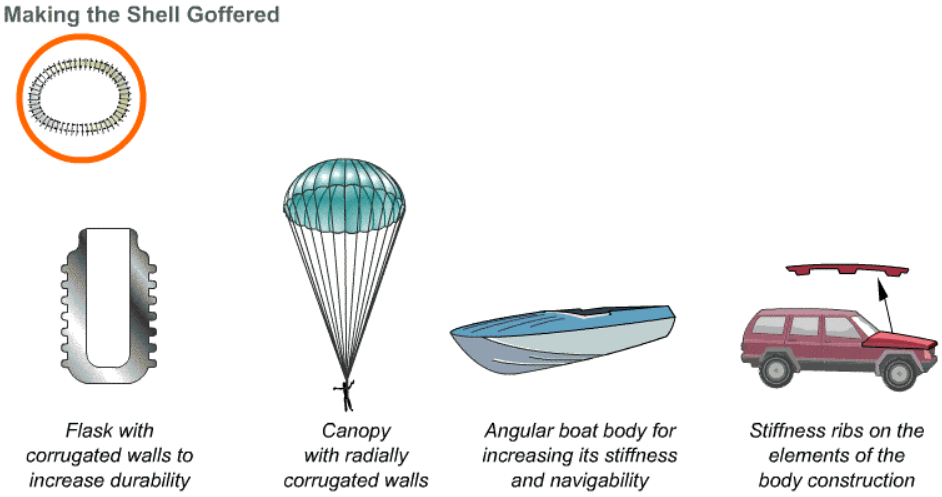


“Introducing a rigid element”.

Vacuum flask. A flask with an additional stiffness rib to increase durability.
Parachute canopy. A canopy with a spring element for accelerating parachute breaking-out.
Boat. A supporting structure inside a boat (canoe).
Car. A reinforcing structure of the body of a racing all-road car. *(Fig. 13)*

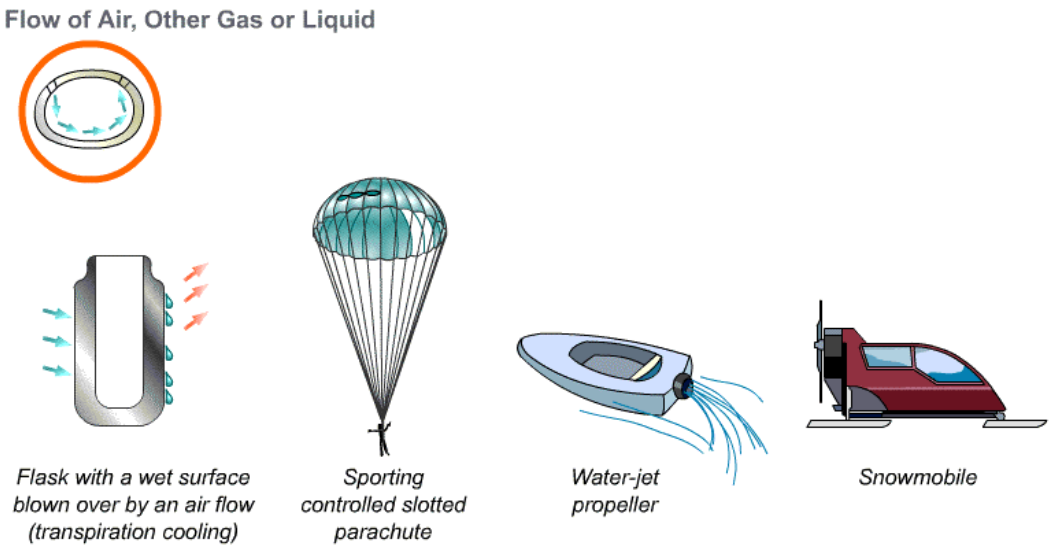


"A shell with corrugations".
Vacuum flask. A flask with corrugated walls to increase durability.
Parachute canopy. A canopy with radially corrugated walls.
Boat. An angular boat body for increasing its stiffness and navigability.
Car. Stiffness ribs on the elements of the body construction. *(Fig. 14)*

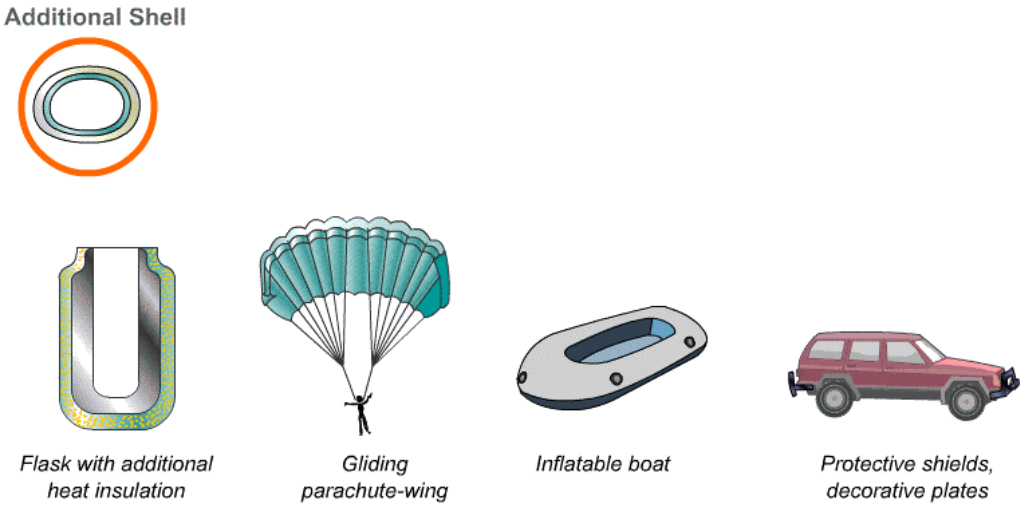


"A flow of air, other gas or liquid".
Vacuum flask. A flask with a wet surface blown over by an air flow (transpiration cooling).

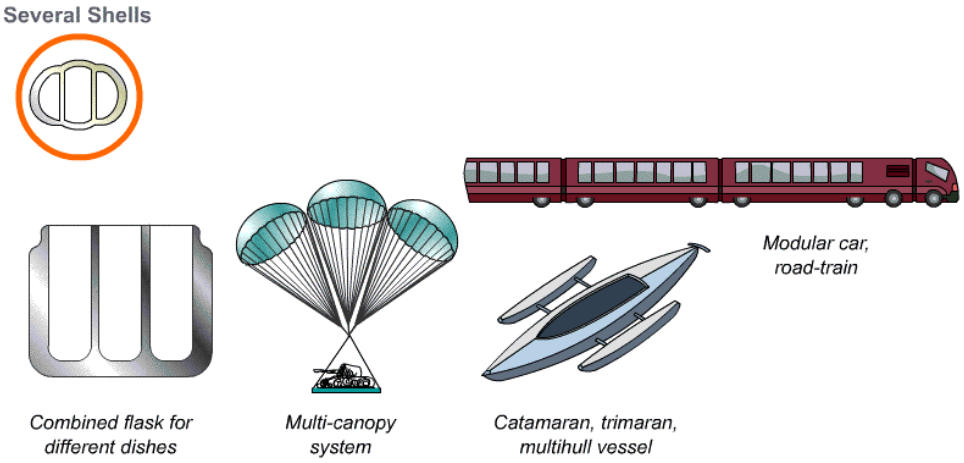
Parachute canopy. A sporting controlled slotted parachute.
Boat. A water-jet propeller.
Car. A snowmobile *(Fig. 15)*



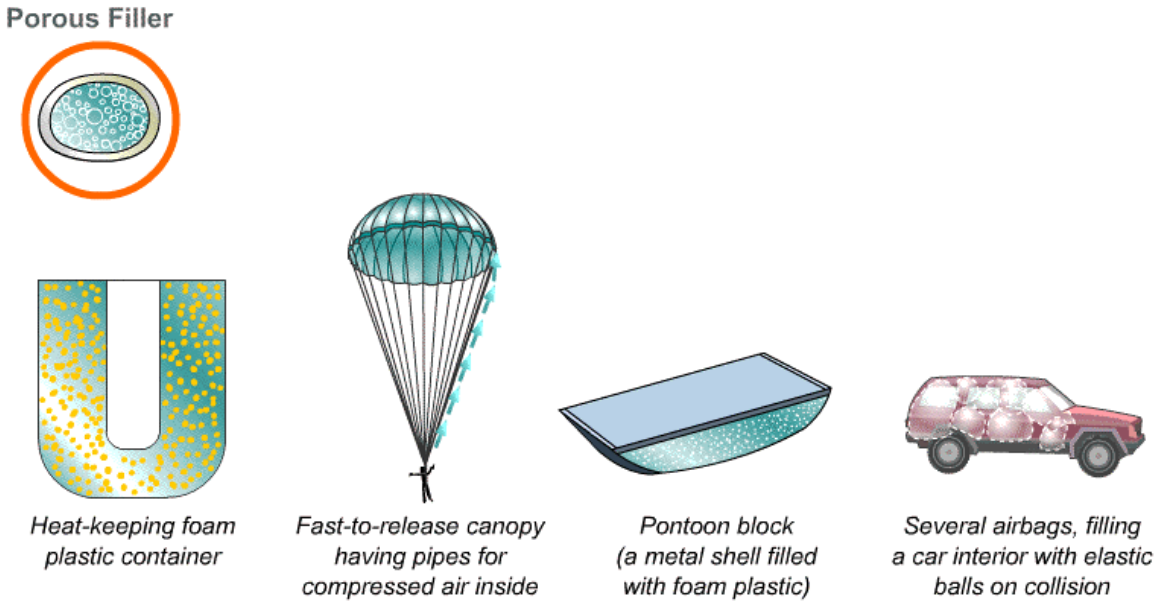
"An additional shell".
Vacuum flask. A flask with additional heat insulation.
Parachute canopy. A gliding parachute-wing.
Boat. An inflatable boat.
Car. Protective shields, decorative plates. *(Fig. 16)*



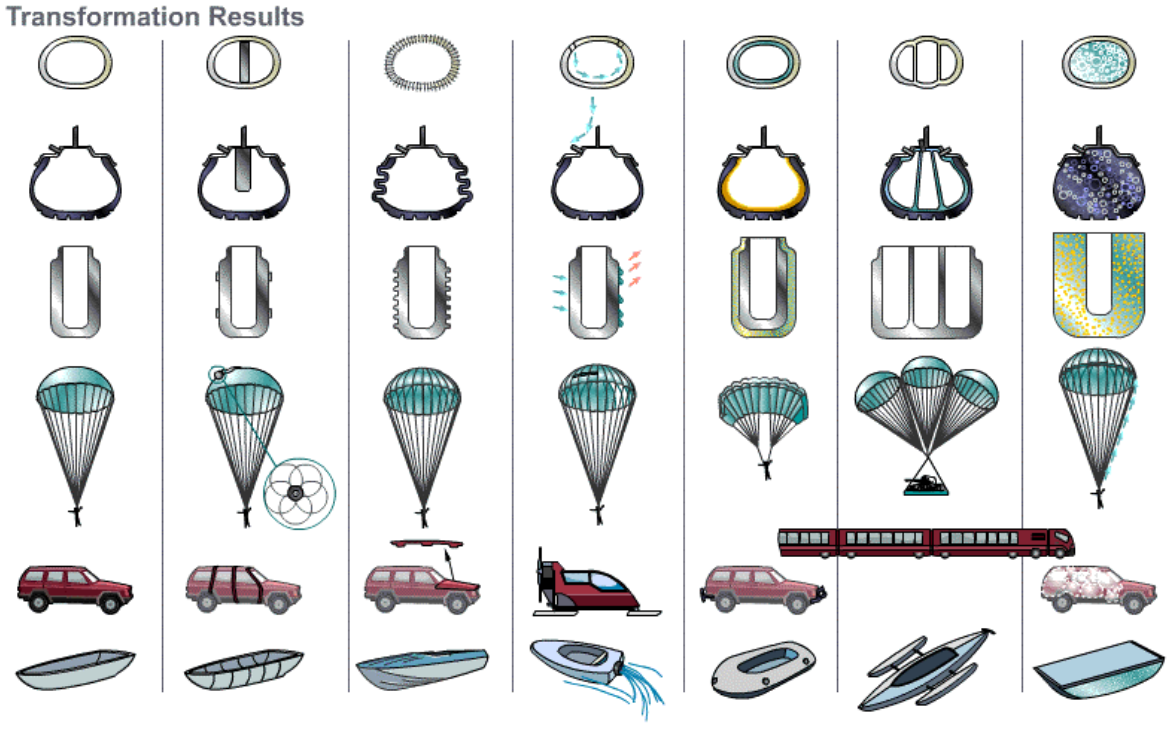
“Several shells”.
Vacuum flask. A combined flask for different dishes.
Parachute canopy. A multi-canopy system.
Boat. A catamaran, trimaran, multihull vessel.
Car. A modular car, road-train. *(Fig. 17)*



“Porous filler”.
Vacuum flask. A heat-keeping foam plastic container.
Parachute canopy. A fast-to-release canopy having pipes for compressed air inside.
Boat. A pontoon block (a metal shell filled with foam plastic).
Car. Several airbags, filling a car interior with elastic balls on collision. *(Fig. 18)*



So all the table cells are filled. *(Fig. 19)*



Conclusion

That the work is going on. Our team investigates and selects the most typical structures for building transformation trees for the most elaborated ones.

Such work may result in a computer system for conducting express-analysis of Engineering Systems in accordance with the employed structural schemes.

Literature

G.Altshuller: 1999. The innovation algorithm. Worchester, Massachusetts: Technical Innovation Center. ISBN 0964074044.

B. Zlotin, A. Zusman G. Altshuller, V. Philatov. Tools of Classical TRIZ

N. Shpakovsky, P. Chuksin, E. Novitskaya. Forecasting Maps of Engineering System Evolution. http://www.gnrtr.com/tools/en/a03.html

N. Shpakovsky, P. Chuksin, E. Novitskaya. Tool for generating and selecting concepts on the basis of trends of engineering systems evolution. TRIZ-Future 2002.